Codes and Standards Enhancement Initiative
For PY2004: Title 20 Standards Development

Analysis of Standards Options for Walk-in Coolers (Refrigerators) and Freezers

Prepared for:
Gary B. Fernstrom, PG&E

Pacific Gas and Electric Company™

Prepared by:
Davis Energy Group
Energy Solutions
May 10, 2004

This report was prepared by Pacific Gas and Electric Company and funded by California utility customers under the auspices of the California Public Utilities Commission

Table of Contents

1 Introduction

The Pacific Gas and Electric Company (PG&E) Codes and Standards Enhancement (CASE) Initiative Project seeks to address energy efficiency opportunities through development of new and updated Title 20 standards. Individual reports document information and data helpful to the California Energy Commission (CEC) and other stakeholders in the development of these new and updated standards. The objective of this project is to develop CASE Reports that provide comprehensive technical, economic, market, and infrastructure information on each of the potential appliance standards. This CASE report covers standards and options for Walk-in coolers (refrigerators) and freezers.

2 Product Description

Walk-in Coolers (refrigerators) and Freezers together referred to hereafter as Walk-ins are medium temperature and low temperature refrigerated spaces that can be walked into (Figure 1)[1]. Not including refrigerated warehouses, which generally have a door large enough for a fork lift to enter, Walk-ins can range from less than 50 square feet of floor space to several thousand square feet, with ceiling heights from 8 to 30 feet. For the purposes of this analysis, we concentrate on Walk-ins that are normally used to maintain pre-cooled materials at refrigerated temperatures and are not designed to rapidly cool down materials from non-refrigerated temperatures. Typical Walk-ins are either low temperature or medium temperature, but may be both, sometimes with access to the low temperature space from the medium temperature space. Smaller Walk-ins usually have only one access door for walking into, and many Walk-ins have reach-in doors for easy access to the refrigerated products and materials. Walk-ins normally have some sort of shelving and are equipped with a protected illumination source, which is often a standard incandescent "A" lamp.

Walk-ins have the basic components of a refrigeration system: evaporator, condenser and compressor. The evaporator is inside and consists of a heat exchanger and fans. The rest of the refrigeration system, specifically the condenser and compressor, can come in one of three configurations: 1) compressor and condenser at the Walk-in (on top or on the side (Figure 2)), 2) compressor at the Walk-in and the condenser remotely located, and 3) compressor and condenser remotely located. The compressor and condenser in each of these scenarios can either supply refrigeration to the Walk-in only or to other equipment also, but the compressor and condenser in scenario one and two usually supply only the Walk-in. Most Walk-ins have dedicated refrigeration systems except in cases where a central refrigeration system is present, such as in grocery stores. In this report the analysis is based on data primarily representative of Walk-ins using dedicated refrigeration systems.

Walk-ins are generally constructed of 3.5", 4" and 5.5" thick insulated panels. The panels are made of polyurethane, polystyrene, or fiberglass sandwiched between two sheets of aluminum or galvanized steel. Studs made of wood (2"x4" and 2"x6") or high-density

[1] Medium temperature Walk-ins (Coolers) operate at temperatures between thirty-five and one degree Fahrenheit and low temperature Walk-ins (Freezers) operate at zero degree Fahrenheit and below.

polyethylene are often used in the panels for structural strength. A majority of Walk-ins are constructed on site and inside a building with most often having been purchased as a complete package, but some are pre-fabricated on skids and placed outside.

Figure 1: Interior Walk-in Door

Figure 2: Exterior Walk-in with roof top condenser.

3 Market Status

3.1 Market Penetration

Most commercial facilities in California that process, supply, sell or prepare perishable food in substantial quantities need a Walk-in. The market for Walk-ins is mature and most facilities that require Walk-in refrigeration have it installed. Based on national data, it is estimated that there are approximately 106,000 Walk-ins in California[2]. The market demand for Walk-ins should continue to grow as California grows.

3.2 Existing and Future Sales

The life of the Walk-in insulated envelope is between 12 to 25 years (ADL 1996). Taking 18 years as an average, California sales are estimated at roughly 6,000 units per year. The refrigeration system life, however, is estimated to be 10 years depending on maintenance and environment. Therefore the refrigeration system will be replaced once or twice during the Walk-in's expected life (ADL 1996). Sales are expected to continue to grow as a result of increasing population and replacements.

3.3 Market Penetration of High efficiency Options

A variety of energy efficiency options are discussed below. Manufacturers stated that because the market is first-cost sensitive, the market penetration of high efficiency

[2] California-wide data is interpolated from national data (ADL, 1996). The national data was multiplied by the ratio of California population to the national population. Thus, it is assumed that California has approximately 12 percent of the nation's Walk-ins.

options is low. Representative, quantitative market penetration data was not readily available at this time.

4 Savings Potential

4.1 Baseline Energy Use

Because more recent baseline energy use data has not been obtained, this analysis relies largely on data from the report *Energy Savings Potential Report for Commercial Refrigeration Equipment*, (ADL 1996). Recent conversations with major manufacturers suggest that Walk-in performance has not changed markedly in the last five years.

California-wide data is interpolated from the ADL report, which provided national statistics, by multiplying the national data by the ratio of California population to the national population. Thus, it is assumed that California has approximately 12 percent of the nation's Walk-ins.

Baseline energy use given in the ADL report was converted into California data in Table 1, which shows the baseline energy usage for an estimated 106,000 Walk-ins to be 2,000 GWh per year (ADL 1996).

Table 1 California Commercial Sector Overview - Walk-in Coolers and Freezers

Unit Type	Estimated Inventory	Average Unit Energy Consumption * (kWh/yr)	Total Energy Consumption, (GWh/yr)	Total Energy Consumption, (%)
Coolers	65,340	16,200	1,100	53
Freezers	33,275	21,400	700	35
Cool-Freezers	7,865	30,200	200	12
Total	106,480		2,000	100

* Includes compressor, fans, lighting, defrost, and anti-sweat
Source: ADL 1996

4.2 Proposed Test Method

There is no current standardized testing procedure for measuring the relative energy efficiency of Walk-ins, though ASHRAE 117-2002 Method of Testing Closed Refrigerators is the appropriate test procedure for refrigerated cases with doors and may be adaptable to Walk-ins. The ASHRAE test method details the purpose, test conditions, instrumentation, test procedures, measurement locations, apparatus, presentation, calculation and reporting of test results for closed refrigerators (ASHRAE 2002).

Walk-ins are generally site-built for logistical reasons and due to the custom nature of the product. Size, location, ambient temperatures, suction temperatures, relative humidity, mechanical systems, etc., vary significantly for each installation, even for the pre-fabricated skid mount Walk-ins. Therefore, physically testing the energy efficiency performance of Walk-ins would be difficult and most likely cost prohibitive. If a performance standard were considered, it would likely need to use computer modeling techniques to account for the infinite variety of Walk-in configurations, similar to the standards used for site-built fenestrations.

4.3 Efficiency Measures

Many efficiency measures are commonly available for Walk-ins. As with many products, features and first-cost are the highest priority for customers and energy consumption is generally a secondary concern. Manufacturers of Walk-ins are, therefore, likely to include efficiency measures only if they are specified in the customer's order but do not generally include them due to the competitive bidding process. Below is a list of efficiency measures or strategies that currently are or could be integrated into Walk-in design:

1) Automatic door closer (for both reach-in and Walk-in doors). This mechanical device automatically closes the door when it is ajar to decrease ambient air infiltration, thus lowering the load on the refrigeration system.

2) Strip curtains. Strip curtains are clear flexible plastic strips that cover the Walk-in door opening and decrease ambient air infiltration when the door is open for stocking purposes. Another variation of this strategy is attaching plastic swinging doors to the doorway of the Walk-in. These options may only be practical in certain applications and are sometimes removed or disabled by employees for making access easier. The persistence of these measures if provided as standard equipment is, therefore, questionable.

3) High efficiency low/no heat reach-in doors. For Walk-ins with reach-in doors, doors with multi-pane glass and gas fill that require lower heat or no heat at all to prevent condensation are available. The increased insulation value of these doors also decreases the heat conducted into the Walk-in and lowers the loading on the refrigeration system.

4) Suction line insulation. Insulating the suction line reduces the additional heat load that is absorbed by the suction line between the Walk-in and the compressor. Suction line insulation is usually only applicable to Walk-ins with remotely located condensing units.

5) Increased envelope insulation. Increased insulation will decrease refrigeration loading due to heat conduction. From the data in Table 4, a 1” increase in insulation has less than a 4-year payback, making it obviously cost effective. Manufacturers stated that typical insulation panels are 3.5 to 4 inches thick for refrigerators and freezer with freezers more often having a full four inches. (Kysor Panel 2003, Tyler/International Cold Storage 2003, Imperial Manufacturing 2003, National Cooler 2003).

6) Evaporative fan controllers. Evaporator fan controllers turn off the evaporator fan when the compressor shuts off. Normally the compressor duty cycle is in the 60 to 70 percent range and the evaporator fans keep running at all times. In some cases continued air circulation is needed to keep the temperature in the Walk-in uniform. In these cases a smaller fan that does not blow through the evaporator can be used to maintain the airflow. This analysis assumes a 20 percent reduction in fan power requirements (ADL 1996).

7) High efficiency evaporator/condenser fans motors. Normally the motors used to drive the evaporator and condenser fans are the less efficient shaded pole motors. Permanent Split Capacitor (PSC) and Electronically Commutated Motors (ECM) are more efficient and use significantly less electricity. Use of efficient motors inside the Walk-in would also reduce internal heat loading.

8) High efficiency lighting. High efficiency lighting (ballast and lamps) will reduce electric load and internal heat load. Changing out the lamps for more efficient T8 or T5 fluorescent lamps with electronic ballasts would increase savings. Smaller Walk-in units generally have an incandescent light source. Greater savings would result from an efficient fluorescent light source. Locating the ballast outside the refrigerated space is another possibility for reducing heat load from lighting.

9) Floating Head Pressure. Allowing the head pressure of the compressor to float at lower ambient temperatures will decrease the load on the compressor. This is possible because of better expansion valve and control technologies.

10) Hot gas defrost. Defrosting of the evaporator and drain is normally accomplished using an electric resistance heater. Using the hot gases from the compressor to defrost the evaporator decreases the electrical load on the Walk-in. Hot gas defrost is most commonly used in low temperature applications.

11) External heat rejection. Walk-ins with condensing units that are located next to, beside, or on top of the unit reject heat into the ambient air directly in contact with the Walk-in. Moving the condensing unit to an external location not only removes the heat source from the ambient air directly in contact with the Walk-in, but also moves the condenser to an area where temperatures can be low enough to take advantage of floating head pressure controls.

12) Defrost controls. Defrosting the evaporator and drain adds heat load to the Walk-in. Defrost cycles are normally on a fixed schedule regardless of the amount of defrost needed. Intelligent defrost controls can sense when defrost is needed and introduce the right amount of heat needed to defrost the unit. For electric defrost, the controls reduce electric load and the extra heat load introduced into the system. For a system using hot gas defrost, an intelligent defrost control helps eliminate the extra heat gain from the hot gas. Defrost is most commonly used in low temperature applications.

13) Anti-sweat heat controls. Anti-sweat heaters are needed to control condensation (sweat) around the access door perimeter and on reach-in merchandising doors. Most anti-sweat heaters stay on even when not needed. A dew point sensor can control the anti-sweat heaters and cycle them off when not needed.

14) High efficiency fan blades. To save costs, fan blades are not normally designed for a specific application, but are generic and used for many different situations even though they may not be optimally designed. Improved design fan blades could result in a 10 to 20 percent reduction in fan power requirements in Walk-in applications (ADL 1996).

15) Ambient subcooling. In the absence of floating head pressure controls, ambient subcooling can be used to save energy. In ambient subcooling, extra heat is rejected after the refrigerant reaches the receiver (where the refrigerant, now a liquid, is collected after rejecting its initial heat in the condensing unit) using a heat exchanger, which further cools the refrigerant and reduces the duty cycle of the compressor and condenser fans.

4.4 Standards Options

Three standards approaches are possible. A prescriptive standard would be easiest to implement and could require selected energy efficiency measures from those listed above. Alternatively, a performance standard relying on a computer modeling “test” procedure would allow manufacturers the flexibility to pick and choose the efficiency measures that best fit their customer's operational concerns.

Another option would be to adopt both a prescriptive and modeling-based performance standard. This approach, analogous to Title 24 compliance methods, would allow the more sophisticated manufacturers options in their design using the performance method and the less sophisticated manufacturers an easy to understand and implement efficiency strategy by using the prescriptive method. This option, however, would not always allow direct efficiency comparisons of competing products if the less sophisticated manufacturer were not capable of modeling their Walk-in.

In this CASE report, the prescriptive approach is recommended and many of the abovementioned efficiency measures are assessed as candidates for inclusion in a package of required, prescriptive measures.

4.5 Energy Savings

Estimates of the energy savings for most of the efficiency measures above are listed in Table 2 and 3. Data in the first columns of Tables 2 and 3 show the nominal energy savings estimated for the measures in the medium and low temperature Walk-ins. For most measures, savings were obtained from ADL 1996 based on a “prototypical” cooler and freezer of 240 and 80 square feet, respectively. Because California-wide average Walk-ins dimensions (also from ADL 1996) vary substantially from the typical Walk-ins modeled by ADL, we scale the savings to reflect the California stock. Savings estimates derived from PG&E 1999 were based on Walk-ins of unknown area, but these three measures scale as a function of either Walk-in door area or display door width and are not likely to be sensitive to differences in floor area. For auto door closers and strip curtains, it is presumed that larger Walk-ins have larger entry doors (larger door area).

As a result of different scaling factors, savings from door closers and low/no heat doors for example cause the total percent savings for Coolers to increase when scaling down to the average Cooler size from the ADL modeled unit. While interaction between measures is to be expected, interaction is not addressed in Table 2 or 3 and instead is captured in the bottom row of Table 4 for the statewide analysis. Given the variety of energy design factors inherent in Walk-ins, which are generally custom-built, and the relative dearth of product characteristics of the California stock and measured performance data, we make the simplifying assumption that most of the ADL savings estimates scale linearly with Walk-in area.

Next, general assumptions about the proportion of coolers, freezers and combination coolers that could accommodate the energy efficiency measures are given. Those portions that are excluded represent Walk-ins that simply would not logically have such a feature (e.g. low heat/no heat doors for Walk-ins coolers without reach-in doors) or those assumed to already have the measure (e.g. a portion of Walk-in sales are presumed to already have auto door closers). Additionally, we assume that certain measures would not be selected together in many cases. For example, it is assumed that Walk-ins will have either evaporator fan controllers with shaded pole motors or more efficient evaporator fan motors without controls (though both could be applied for maximum efficiency). These estimates are subject to considerable uncertainty. Next, Table 4 takes the data from Tables 2 and 3 to calculate the total energy saving potential for Walk-ins in California.

Based on the prescriptive measures proposed in Section 7, we estimate energy savings to be approximately 500 GWh when the stock fully turns over. This would equate to roughly 65 MW of peak demand reduction using a refrigeration load factor of 0.87 (Brown, 2003). First years savings are estimated to be approximately 28 GWh and 4 MW of peak demand reduction.

Table 2: Walk-in Cooler Energy Savings Potential in California

	Walk-in Cooler	ADL/PG&E Energy Savings (kWh/year)	Relative Savings (%)	Savings Scaled to CA Average Unit	Scaled Relative Savings (%)
1	Floating Head Pressure	7,744	18%	2,959	18%
2	Ambient Subcooling	3,872	9%	1,479	9%
3	Anti-sweat Heat Controls	1,004	2%	384	2%
4	Thicker Insulation	190	0%	73	0%
5	Evaporator Fan Control	1,811	4%	692	4%
6	ECM Evaporator Fan Motors	3,574	8%	1,366	8%
7	ECM Condenser Fan Motors	925	2%	353	2%
8	Electronic Ballasts (Lighting)	440	1%	168	1%
9	High Efficiency Fan Blades	2,666	6%	1,019	6%
10	Strip Curtains	3,730	9%	2,798	17%
11	Low Heat/No Heat Doors	3,130	7%	3,130	19%
12	Auto Door Closer	3,535	8%	2,651	16%
13	Proposal Combination*	9,755	22%	5,995	37%

*Assumes Items 7, 8, 12, and average of 3 and 11, and average of 5 and 6

Notes:

1. The ADL data (items 1-9) are based on a 240 square foot Walk-in cooler using 42,400 kWh/year
2. The PG&E data for items 10 and 12 is based on door area and thus is not sensitive for Walk-in area. It is assumed that average door area is 25% smaller than the ADL model due to the difference in size of the ADL Walk-in prototype versus the smaller average California Walk-in cooler.
3. Low Heat/No Heat Doors savings is based on an overall stock average of 10 linear feet and is estimated as an average of both coolers and freezers assuming one in five Walk-ins is a freezer and the other four are coolers. We apply this average to both coolers and freezers in this analysis.

Table 3: Walk-in Freezer Energy Savings Potential in California

	Walk-in Freezer	ADL/PG&E Energy Savings (kWh/year)	Relative Savings (%)	Savings Scaled to CA Average Unit	Scaled Relative Savings (%)
1	External Heat Rejection	1,466	9%	2,011	9%
2	Hot Gas Defrost	589	4%	808	4%
3	Defrost Controls	368	2%	505	2%
4	Anti-Sweat Heat Controls	1,008	6%	1,383	6%
5	Thicker Insulation	566	4%	776	4%
6	Evaporator Fan Controls	631	4%	866	4%
7	ECM Evaporator Fan Motors	2,208	14%	3,029	14%
8	ECM Condenser Fan Motors	1,067	7%	1,464	7%
9	High Efficiency Fan Blades	776	5%	1,065	5%
10	Strip Curtains	3,730	24%	5,117	24%
11	Low Heat/No Heat Doors	3,130	20%	4,294	20%
12	Auto Door Closer	3,535	23%	4,849	23%
13	Proposal Combination*	8,657	55%	11,875	55%

*Combination includes the average of 4 and 11 and the average of 6 and 7, as well as 5,8, and 12

Notes:

1. The ADL data (items 1-9) are based on an 80 square foot Walk-in freezer using 15,600 kWh/year
2. The PG&E data for items 10 and 12 is based on door area and thus is not sensitive for Walk-in area.
3. Low Heat/No Heat Doors savings is based on an overall stock average of 10 linear feet and is estimated as an average of both coolers and freezers assuming one in five Walk-ins is a freezer and the other four are coolers. We apply this average to both coolers and freezers in this analysis.

Table 4: Total Walk-in Energy Savings Potential in California

	Walk-ins	Relative Savings		Proportion of Walk-ins Affected		
		Cooler	Freezer	Cooler	Freezer	Combo
3	Anti-sweat Heat Controls	2%	6%	20%	50%	25%
4	Thicker Insulation	0%	4%	50%	50%	50%
5	Evaporator Fan Control	4%	4%	50%	50%	25%
6	ECM Evaporator Fan Motors	8%	14%	50%	50%	25%
7	ECM Condenser Fan Motors	2%	7%	100%	100%	50%
8	Electronic Ballasts (Lighting)	1%	5%	30%	20%	10%
11	Low Heat/No Heat Doors	19%	20%	25%	25%	25%
12	Auto Door Closer	16%	23%	40%	40%	40%
13	Total Savings (less interaction)*					

*Total Savings Amounts are reduced by 20% to account for interaction effects between measures

Table 4 (Continued)

Walk-ins		First Year Annual Energy Savings (GWh)	Full Potential Annual Energy Savings (GWh)	Full Potential Peak Demand Reduction (MW)
	Walk-in Type	All	All	All
3	Anti-sweat Heat Controls	2	37	4.8
4	Thicker Insulation	1	19	2.5
5	Evaporator Fan Control	3	46	6.0
6	ECM Evaporator Fan Motors	7	118	15.5
7	ECM Condenser Fan Motors	5	81	10.6
8	Electronic Ballasts (Lighting)	1	16	2.2
11	Low Heat/No Heat Doors	7	128	16.7
12	Auto Door Closer	10	174	22.9
13	Total Savings (less interaction)*	28	496	65

*Total Savings Amounts are reduced by 20% to account for interaction effects between measures

5 Economic Analysis

5.1 Incremental Cost

As with many products, first cost is an important consideration in the minds of purchasers. Table 5 below shows the estimated incremental costs for several of the efficiency measures described earlier. The incremental cost data was obtained from ADL 1996 and Express Efficiency program regulatory filings from the California IOUs.

Table 5: Incremental Costs for Walk-in Coolers

	Walk-in Cooler	ADL Incremental Cost ($)	PG&E Incremental Costs ($)	Incremental Costs Scaled to CA Average Unit ($)	Annual Energy Savings (kWh)	Value of Saved Energy ($)	Simple Payback (years)
1	Floating Head Pressure	207		207	2,959	174	1.2
2	Ambient Subcooling	624		624	1,479	87	7.2
3	Anti-sweat Heat Controls	594		594	384	23	26.3
4	Thicker Insulation	509		194	73	4	45.5
5	Evaporator Fan Control	119		119	692	41	2.9
6	ECM Evaporator Fan Motors	418		418	1,366	80	5.2
7	ECM Condenser Fan Motors	71		71	353	21	3.4
8	Electronic Ballasts (Lighting)	95		36	168	10	3.7
9	High Efficiency Fan Blades	143		143	1,019	60	2.4
10	Strip Curtains		64	64	2,798	165	0.4
11	Low Heat/No Heat Doors		770	578	3,130	184	3.1
12	Auto Door Closer		125	125	2,651	156	0.8
13	Proposal Combination*	986	510	1,184	5,995	353	3.4

*Assumes Items 7, 8, 12, and average of 3 and 11, and average of 5 and 6

1. The ADL data (items 1-9) are based on a 240 square foot Walk-in cooler using 42,400 kWh/year
2. Low Heat/No Heat Doors incremental cost is based on an overall stock average of 10 linear feet and is an average of both coolers and freezers assuming one in five Walk-ins is a freezer and the other 4 are coolers. We apply this average to both coolers and freezers in this analysis.
3. Using PG&E E-19 rate schedule assuming constant loading and no adders

It should be noted that for the ECM motor measures in the tables above and below, at somewhat lower cost ($160 for Coolers and $60 for Freezers), permanent split capacity (PSC) motors could be used instead. Use of PSC motors would result in approximately 25 and 40 percent lower savings for Freezers and Coolers, respectively.

Table 6: Incremental Costs for Walk-in Freezers

Walk-in Freezer	ADL Incremental Cost ($)	PG&E Incremental Costs ($)	Incremental Costs Scaled to CA Average Unit ($)	Annual Energy Savings (kWh)	Value of Saved Energy ($)	Simple Payback (years)
1 External Heat Rejection	951		951	2,011	118	8.0
2 Hot Gas Defrost	99		99	808	48	2.1
3 Defrost Controls	119		119	505	30	4.0
4 Anti-Sweat Heat Controls	594		594	1,383	81	7.3
5 Thicker Insulation	138		189	776	46	4.1
6 Evaporator Fan Controls	119		119	866	51	2.3
7 ECM Evaporator Fan Motors	119		119	3,029	178	0.7
8 ECM Condenser Fan Motors	57		57	1,464	86	0.7
9 High Efficiency Fan Blades	39		39	1,065	63	0.6
10 Strip Curtains		64	64	5,117	301	0.2
11 Low Heat/No Heat Doors		770	770	4,294	253	3.0
12 Auto Door Closer		125	125	4,849	286	0.4
13 Proposal Combination*	611	510	1,172	11,875	781	1.5

*Combination includes the average of 4 and 11 and the average of 6 and 7, as well as 5, 8, and 12.

Notes:

1 The ADL data (items 1-9) are based on a 240 square foot Walk-in cooler using 42,400 kWh/year
2 The PG&E data for items 10 and 12 is based on door area and thus is not sensitive for Walk-in area per se,
3 Low Heat/No Heat Doors savings is based on an overall stock average of 10 linear feet and is estimated as an average of both coolers and freezers assuming one in five Walk-ins is a freezer and the other 4 are coolers. We apply this average to both coolers and freezers in this analysis. based we assume on units closer in size to ADL model
4 Using PG&E E-19 rate schedule assuming constant loading and no adders

4.1 Design Life

ADL provided estimates of design life ranging from 12 to 25 years for envelope components and from 8 to 12 years for refrigeration components. The presumed design lives, for products offered rebates by utility incentive programs, are available from California IOU program filings (PG&E, 1999). We assumed an average of ten years for most refrigeration system components and 18 years for envelope components.

4.2 Life Cycle Cost

Life cycle costs for the measures in Table 2 and 3 are presented below in Table 7 and 8. The present value of savings were calculated using a Life Cycle Cost of $0.35, $0.588, $0.709 and $1.002 per annual kWh savings for 4, 8, 10 and 18 year measures, respectively (CEC 2001).

Table 7: Analysis of Customer Net Benefit -- Walk-in Coolers

Walk-in Cooler	Design Life (years)	Annual Unit Savings (kWh)	Present Value Factor ($/kWh)	Present Value of Energy Savings	Increment al Costs ($)	Consumer Net Present Value ($)
Floating Head Pressure	10	2,959	0.709	2,098	207	1,891
Ambient Subcooling	10	1,479	0.709	1,049	194	854
Anti-sweat Heat Controls	10	384	0.709	272	119	153
Thicker Insulation	18	73	1.002	73	418	(345)
Evaporator Fan Control	10	692	0.709	491	71	420
ECM Evaporator Fan Motors	10	1,366	0.709	968	36	932
ECM Condenser Fan Motors	10	353	0.709	251	143	108
Electronic Ballasts (Lighting)	10	168	0.709	119	64	55
High Efficiency Fan Blades	18	1,019	1.002	1,021	578	443
Strip Curtains	4	2,798	0.350	979	125	854
Low Heat/No Heat Doors	18	3,130	1.002	3,136	1,184	1,952
Auto Door Closer	8	2,651	0.588	1,559	-	1,559
Proposal Combination*		5,995		4,399	1,121	3,278

*Assumes Items 7, 8, 12, and average of 3 and 11, and average of 5 and 6

Table 8: Analysis of Customer Net Benefit -- Walk-in Freezers

Walk-in Freezer	Design Life (years)	Annual Unit Savings (kWh)	Present Value Factor ($/kWh)	Present Value of Energy Savings	Increment al Costs ($)	Consumer Net Present Value ($)
1 External Heat Rejection	10	2,011	0.709	1,426	84	1,342
2 Hot Gas Defrost	10	808	0.709	573	34	539
3 Defrost Controls	10	505	0.709	358	21	337
4 Anti-Sweat Heat Controls	10	1,383	0.709	980	58	923
5 Thicker Insulation	18	776	1.002	778	46	732
6 Evaporator Fan Controls	10	866	0.709	614	36	578
7 ECM Evaporator Fan Motors	10	3,029	0.709	2,148	126	2,021
8 ECM Condenser Fan Motors	10	1,464	0.709	1,038	61	977
9 High Efficiency Fan Blades	18	1,065	1.002	1,067	63	1,004
10 Strip Curtains	4	5,117	0.350	1,791	105	1,685
11 Low Heat/No Heat Doors	18	4,294	1.002	4,302	253	4,049
12 Auto Door Closer	8	4,849	0.588	2,851	168	2,683
13 Proposal Combination*		11,875		8,689	512	8,177

*Combination includes the average of 4 and 11 and the average of 6 and 7, as well as 5, 8, and 12

5 Acceptance Issues

5.1 Infrastructure Issues

No major infrastructure issues are known at this time. The larger manufacturers of Walk-ins are Imperial Manufacturing, Kysor Warren, Crown Tonka, National Cooler (Hill Phoenix), International Cold Storage, and Master-Bilt. Walk-ins are bid and built to the customer's specification. Due to cost competition among bidders, if the customer does not specify energy efficient components, they are not likely to be included in the winning proposal. First cost is a main driver in the purchase decision. Large supermarket and convenience store chains are key customers of this product category. These customers will be the main group that is concerned about efficiency and its cost. The energy efficiency measures recommended below are cost-effective and readily available.

5.2 Existing Standards

There are no known existing standards at this time.

6 Recommended Standard

Insufficient performance data and a lack of an accepted test procedure prevent establishing a performance-based standard at this time. As was noted in section 4.2, given the physical size, logistical issues, and the custom-built nature of this product, performance-based standards would likely have to be based on computer modeling rather than physical testing. Specifying or developing an appropriate model is beyond the scope of this CASE study.

A prescriptive standard is the most feasible near- and intermediate-term standards approach for Walk-ins and is, therefore, proposed. The package of prescriptive measures proposed below would be relatively easy to implement in a short time frame and the technologies are readily available. Major manufacturers that were contacted expressed little or no opposition or even support for prescriptive standards requiring certain energy efficiency measures that are readily available (Imperial Manufacturing, 2003, Hill Phoenix/National Cooler, 2003, Tyler/International Cold Storage, 2003). The following measures are recommended for a prescriptive standard primarily for their universal application on all types of Walk-ins (with or without a dedicated refrigeration unit). These measures account for over one-third of the energy savings opportunity identified and appear quite cost effective.

Proposed required measures for Walk-ins:

1) **Automatic door closer.** Walk-ins must have automatic door closers that firmly close reach-in glass doors. Walk-in doors on Walk-ins must be able to firmly close the door when left within one inch of full closure.

Title 20 should state *"Automatic door closer. Automatic door closers shall be installed. Automatic door closers for reach-in doors must be able to firmly close the door, and for walk-in doors they must be able to close the door when within one inch of full closure."*

2) **High efficiency low/no heat reach-in doors**. Transparent reach-in doors for Walk-ins must have triple pane glass windows with heat-reflective treated glass and/or gas fill. Furthermore, if transparent reach-in doors have anti-sweat heaters, the anti-sweat heaters must be either controlled by anti-sweat heater controls or not have an anti-sweat frame heater power consumption in excess of 40 watts per foot of door frame for low temperature doors and 17 watts per foot of door frame for medium temperature doors.

For units with anti-sweat heater controls, such controls must sense the relative humidity in the air outside of the door and turn off or substantially reduces the power to the anti-sweat heater when there is minimal risk of condensation build up. Equivalent technologies that can reduce the average energy consumption of the anti-sweat heater based on the amount of condensation formed on the inner glass pane will also meet this standard.

Title 20 should state *"High efficiency low/no heat reach-in doors. Transparent reach-in doors for Walk-ins must have triple pane glass doors with heat-reflective treated glass or gas fill. Also, for transparent reach-in doors with anti-sweat heaters that are not controlled by anti-sweat heat controls, the total door rail, glass, and frame heater power draw cannot exceed 40 Watts per foot of door frame width for freezer doors and 17 Watts per foot of door frame width for refrigerator doors. For transparent reach-in doors for Walk-ins with anti-sweat heaters that do have anti-sweat heater controls and that do not meet the maximum power requirements noted above, such anti-sweat controls must sense the relative humidity in the air outside of the door and turn off or reduces the energy use of the anti-sweat heater. Other types of anti-sweat controls technologies that equivalently reduce the energy consumption of the anti-sweat heater based on the amount of condensation formed on the inner glass pane also meet this standard."*

3) E**nvelope insulation**. Insulation R-values can vary greatly depending on the type of insulation used (e.g., fiberglass, polystyrene, polyurethane), so the thickness of a panel does not always ensure an adequate insulation value. Therefore, a standard for a minimum insulating material R-value is recommended rather than requiring a minimum thickness, which depending on the type of insulation could result in non-cost-effective dimensional increases. Given recent changes in the manufacturing materials (blowing agents) that have lowered the R values for polyurethane, the recommended R values are slightly less than stated in the ADL report for freezers, but are consistent with current R values for 4" and 5" polyurethane panels according to manufacturers. For medium temperature Walk-ins a minimum R-value of 28 and for low temperature a minimum R-value of 36 is recommended. Please note that this is a minimum requirement and does not compare precisely with the "increased insulation thickness" option shown in the tables as both savings and incremental costs would be lower. This requirement does not generally require increased wall dimensions, but simply seeks to eliminate inferior insulation within the existing wall dimensions that some manufacturers are using. The values proposed are for the R-value of the insulation itself, not the overall wall R-value.

Title 20 should state *"Envelope Insulation. The minimum envelope insulation level is R-28 for Walk-in refrigerator applications and R-36 for freezer applications."*

4) **High efficiency evaporator/condenser fans motors OR Evaporative fan controllers**. Walk-ins must have either high efficiency evaporator fan motors or evaporative fan controllers. Given the substantial duty cycle of evaporative fan motors, we recommend a standard that prohibits the use of shaded pole or split phase motors, the efficiencies of which range from below 20% to mid-30%, without the use of an evaporator fan controller. Eliminating shaded pole and split phase motors is expected to increase typical motor efficiencies to the 50% to 70% range. Furthermore, Walk-ins with refrigeration systems dedicated to that Walk-in only should not be allowed the use of shaded pole or split phase motors.

Title 20 should state *"Evaporative Fan Controllers and High Efficiency Fan motors. An evaporative fan controller is required if shaded pole or split phase evaporator fan motors are installed. Self contained compressor/condenser units (dedicated to the Walk-in cabinet, including remote units) are prohibited from employing shaded pole or split phase motors*."

5) **High efficiency lighting**. Only high efficiency lighting consisting of T8/T5 lamps and low temperature electronic ballasts or other lighting systems with equal or better LPW efficacy should be should be required and would require little if any reengineering of the Walk-in.

Title 20 should state *"High efficiency lighting. Internal illumination shall be only by (1) T-8 fluorescent lamps with electronic ballasts, or (2) a lighting system that has no fewer lumens per watt than a system using only T-8 fluorescent lamps with electronic ballasts."*

7 References

ANSI/ASHRAE Standard 117-2002, Method of testing Closed Refrigerators

Arthur D. Little (ADL). 1996. "Energy Savings for Commercial Refrigerated Equipment", June 1996

Brown, Richard E. and Jonathon G. Koomey, 2003. *Electricity use in California: past trends, and present usage patterns.* Energy Policy 31 (2003) 849- 864.

California Energy Commission (CEC), 2001. *2001 Update, Assembly Bill 970 Appliance Efficiency Standards Life Cycle Cost Analysis*. P400-01-028, Table 12A. Sacramento, CA. California Energy Resources Conservation and Development Commission.

Hill Phoenix, 2002. Personal conversations with Michelle Lyn of Hussman.

Hill Phoenix/National Cooler , 2003. Personal conversations with Steve Lee of Hill Phoenix/National Cooler.

Hussman, 2002. Personal conversations with Scott Bates and Jed Ingram of Hussman.

Imperial Manufacturing, 2003. Personal conversation with Carl Schoffstoll of Imperial Manufacturing (for Hussman).

Kysor Panel, 2002. Personal conversations with Sharon Boyd and Fred Minelli of Kysor Panel)

Kysor Panel, 2003. Personal conversations with Marion Brown of Kysor Panel

National Cooler, 2003. Personal conversations with Skip Nau of National Cooler.

Pacific Gas and Electric Company, 1999. 2000/2001 Energy Efficiency Programs Application Attachment 12 Workpapers. San Francisco 1999.

Tyler/International Cold Storage, 2003. Personal conversations with Feras Affani of Tyler/International Cold Storage.